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Quebec and Maritimes Regions
Canadian Science Advisory Secretariat
Science Advisory Report 2008/061

SCIENCE ADVICE ON HARVESTING OF NORTHWEST ATLANTIC GREY SEALS (*Halichoerus grypus*) IN 2009

Male and female (foreground) grey seal. Photograph by W. D. Bowen

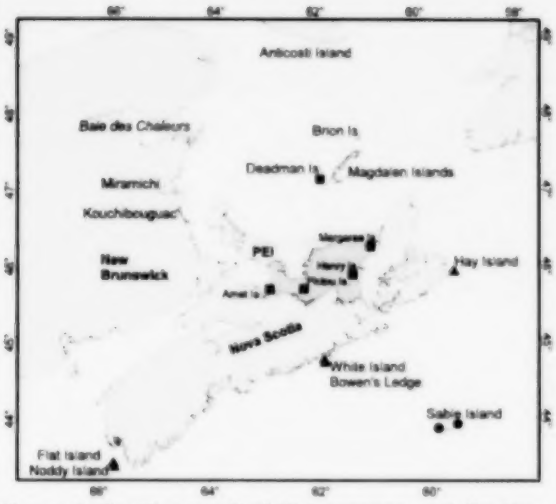

Figure 1: Southern gulf of St Lawrence and Scotian Shelf showing location of Sable Island (●), Eastern Shore (▲), Gulf (■) grey seal colonies and general location of ice-breeding animals (dark grey area). The Eastern Shore encompasses the east coast of Nova Scotia, from approximately Noddy Island to Hay Island.

Context :

Grey seals are managed under the Objective Based Fisheries Management (OBFM) approach, for Atlantic seals which was implemented in 2003. Under this approach, populations are classified as 'Data Rich' or 'Data Poor' depending on certain data criteria. In 2007, grey seals were considered to be 'Data Rich'. The management objective is to maintain an 80% probability (L20) that the population will remain above 70% (N_{70}) of the largest population seen. For grey seals with a population of 300 000 animals, N_{70} is 210 000 animals.

There is a small commercial hunt for grey seals in the Gulf of St. Lawrence and along the Eastern Shore. Grey seals on Sable Island are currently protected. Grey seals are perceived as a nuisance to commercial fisheries and some are killed under a nuisance seal permit. They are an important host for the seal/cod worm (Pseudoterranova decipiens), which also infect many groundfish species, and must be removed during processing. Grey seals are also considered by industry to be affecting the recovery of some depleted fish stocks, and to damage fishing gear. Evidence of the impact of grey seal predation on depleted stocks is inconclusive and there is no current information on the extent of gear damage caused by seals.

The status of the population was assessed in 2007. This advice was developed to examine the impacts of different harvest scenarios on the population

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SUMMARY

- Grey seals form a single genetic population that can be divided into three groups based on the location of breeding sites. Most pups (81%) are born on Sable Island, 15% are born in the Gulf of St. Lawrence and 4% are born along the Eastern Shore of Nova Scotia. This distribution has changed over time, with a decline in the fraction of the population born on the ice compared to on small islands, and an increase in the proportion of animals born on the Eastern Shore, compared to the Gulf.

- Using aerial surveys, total production of Northwest Atlantic grey seals in 2007 was 67,500 (SE=1,400). This includes 54,500 (SE=1,300) pups born on Sable Island, 3,000 (SE=40) along the eastern shore of Nova Scotia, and 9,900 (SE=600) in the Gulf of St. Lawrence.

- Incorporating this information into a population model results in a total population of 300 000 animals (95% CL 240,000-370,000).

- Removals from the population during the last five years include animals taken in the commercial harvest, scientific collections, nuisance seal removals and incidental catches in commercial fisheries. No information is available on incidental catches, and data on number of seals killed as nuisance seals are limited.

- Eight Total Allowable Catch (TAC) scenarios with different age compositions (50% Young of Year [YOY], 50% 1+ animals; 90% YOY, 10% 1+ animals) and four catch levels (15,000, 30,000, 40,000 and 50,000 animals) were examined.

- Model results indicated that seven out of eight scenarios would respect the management objective that the predicted L20 remains above 210,000 during the next five years. The model predicted that L20 would decline below 210,000 with a harvest of 50,000 animals, and an age composition of 50% YOY and 50% 1 + animals.

- Dividing a TAC of 15,000 animals among the three regions would result in a harvest allocation of 11,941, 2,378 and 666 animals for Sable Island, Gulf of St. Lawrence and Eastern Shore, respectively.

- For a TAC of 30,000 animals, the allocation would be 23,882, 4,756, and 1,332 animals for the Sable Island, Gulf of St. Lawrence and Eastern shore herds, respectively.

- The nature and extent of density dependence in vital rates is poorly understood and may change over time. How density dependence acts on vital rates will have an impact on sustainable harvest scenarios.

BACKGROUND

Seals in Atlantic Canada are managed under an Objective Based Fisheries Management (OBFM) approach, first implemented in 2003. Under this approach, populations that have been surveyed at least three times over a 15 year period, with the last survey less than five years old, and having current data on reproduction or mortality (≤5 years old) are considered 'Data Rich'. With the most recent survey in 2007, grey seals have been classified as 'Data Rich'. The

results of this assessment are outlined in DFO 2008. Harvest levels for Data Rich populations are set to maintain an 80% probability that the predicted population trajectory will remain above 70% of the maximum observed population size during the duration of the management plan. This trajectory is referred to as L20.

Fisheries and Aquaculture Management has requested advice on a total allowable catch (TAC) for NW Atlantic grey seals that would maintain an 80% probability that the population would remain above N_{70} or 70% of the largest population observed. The most recent assessment, which is the largest observed for grey seals, estimated the population to number approximately 300,000 seals, resulting in an N_{70} of 210,000. The objective of this paper is to present potential TAC levels that are compliant with this management framework.

Species Biology

The grey seal is a member of the family Phocidae that was first described by Fabricius (1791). Its name *Halichoerus* comes from the Greek meaning "sea pig", and *grypus* from the Latin meaning hook-nosed. In Canada, they are sometimes referred to as horse-head seals owing to the elongated snout of adult males. Males tend to be darker than females, in some cases almost black. They may reach a length of 231 cm, and weigh as much as 350 kg. Females are smaller, reaching 201 cm in length and weigh up to 227 kg. Breeding occurs on islands, isolated beaches or on the pack ice. Pups are born with a white lanugo, which they begin to shed approximately 15 days after birth and is completely replaced with a black spotted, silver coat by the time pups are 25 days old. The Northwest Atlantic grey seal forms a single population that is divided into three components (Gulf, Eastern Shore and Sable Island), for management considerations based on the locations of the major pupping concentrations.

Grey seals are considered to be a coastal or continental shelf species. They haul out on exposed reefs or on beaches of undisturbed islands. These concentrations of animals are typically quite noisy, and are associated with vocalizations resembling growls and roars. These noises sometimes resemble the calling of a wolf, and this may be the source of the general French term "loups marins or sea wolves".

Grey seals were at one time very abundant, and widely distributed along the Canadian east coast, and in the Gulf of St Lawrence where they were first hunted by Amerindians. Extensive hunting by Europeans, resulted in the depletion of the grey seal population by the mid-1800's. Up to the 1950's, the grey seal was considered uncommon or rare, but they continued to be hunted. Some grey seals were taken in a bounty program focused on harbour seals (*Phoca vitulina*). A grey seal culling program at the breeding sites in the Gulf of St. Lawrence and along the Eastern Shore occurred between 1967 and 1984, removing between 114 to 2,375 animals per year. From 1978 until 1990, a bounty was paid to licenced fishermen who submitted lower jaws from grey seals, and information on date and location of capture. A total of 4,379 individuals was taken during this program. Captures were initially quite high, but with the exception of a large number of returns in 1987 (753), they declined steadily until 1990, when only 79 returns were received.

Human Induced Mortality

There is a small commercial harvest for grey seals (Table 1). Over the last five years an average of 655 animals have been removed per year. Harvests occur in the Gulf of St. Lawrence and along the Eastern Shore. Grey seals are protected on Sable Island. Some grey

seals have been killed under a Nuisance seal permit provision of the Marine Mammal Regulations. A total of 484 nuisance seal permits was issued in 2007, with 99% of these issued in Nova Scotia (the Maritimes Region). Only 91 seals have been reported killed, but statistics are incomplete. Some animals are removed as part of Department of Fisheries and Oceans scientific sampling programs to study diet, growth and reproductive rates. This program has removed 347 seals in the last 5 years. Grey seals may also be taken as incidental catch in commercial fisheries, but no data are available on the magnitude of this mortality.

Table 1. Reported removals from the NW Atlantic grey seal population over the last six years.

	2003	2004	2005	2006	2007	2008
Commercial harvest	6	0	579	1804	887	1472
Science collections	85	199	15	22	26	No Data
Nuisance seals	No Data	No Data	No Data	No Data	91	No Data
Incidental catch	No Data	No Data	No Data	No Data	No Data	No Data

ASSESSMENT

The total number of grey seals in the northwest Atlantic is based on a population model that incorporates independent estimates of pup production with data on reproductive rates (female age at first birth and age specific pregnancy rates), mortality rates and catches including struck and lost. Pup production has been determined from a series of total counts (Sable Island), mark-recapture (Gulf) or aerial surveys and total counts (Table 2, 3).

Table 2. Estimates of Non-Sable (Gulf and Eastern Shore) grey seal pup production, from mark-recapture (M-R) and aerial surveys, rounded to the nearest 100. The mark-recapture method was replaced after 1990 by aerial survey methods. Standard errors are in brackets.

Year	Mark-recapture estimates	Aerial survey estimates
1984	7,200 (900)	
1985	6,700 (800)	
1986	5,600 (700)	
1989	9,700 (900)	
1990	9,000 (600)	
1996		11,100 (1,300)
1997		7,300 (800)
2000		6,100 (900)
2004		15,600 (1,200)
2007		13,000 (600)

Table 3. Estimates of Sable grey seal pup production, total count and aerial surveys. Standard errors are in brackets.

Year	Total counts	Aerial survey estimates
1984	5,900 (300)	
1985	5,600 (300)	
1986	6,300 (300)	
1987	7,400 (300)	
1988	8,600 (300)	
1989	9,700 (400)	
1990	10,500 (600)	
1993		15,500 (463)
1997		25,400 (750)
2004		41,500 (4,381)
2007		54,500 (1,288)

Combining estimates from the Sable and non-Sable Island components of the population, total production of Northwest Atlantic grey seals was (67,500) (SE=1,400) in 2007. This includes 54,500 (SE=1,300 pups born on Sable Island, 3,000 (SE=40) along the eastern shore of Cape Breton Island and Nova Scotia, and 9,900 (SE=600) in the Gulf of St. Lawrence. Approximately 81% of pups are born on Sable Island, 15% are born in the Gulf and 4% are born along the Eastern Shore.

Population Model

A Bayesian model was fitted to available pup production data from 1977-2007, to examine the dynamics of the Northwest Atlantic grey seal population. The population was divided into three breeding regions: Sable Island, Gulf of St Lawrence, and Eastern Shore of Nova Scotia. The model assumes that fecundity rates are age-dependent, but are constant over time, that adult survival rates are constant, and that pup survival is density dependent. Females are allowed to move from their natal area to a new region to breed, but once they start breeding they do not move. A Bayesian computer-intensive method was used to fit the model, with informative priors on model parameters. The posterior estimates for some parameters were close to their priors indicating that there was little information about these parameters in the pup production data. Other parameters were far from the prior: in particular the posterior estimates of carrying capacity were far higher than the prior values, indicating little evidence of density-dependent population regulation at current levels of pup production.

The total estimated population size in 2007 was 304,000 (95% Credibility interval=242,000-371,000)(Fig. 2). This is much higher than the 1977 estimate of 41,000 (95% Credibility Interval=31,000-51,000). Average annual rates of population increase are estimated to be 4% in the 1980s (lower due to greater harvests in the Gulf), 9% in the 1990s and 8% in the 2000s.

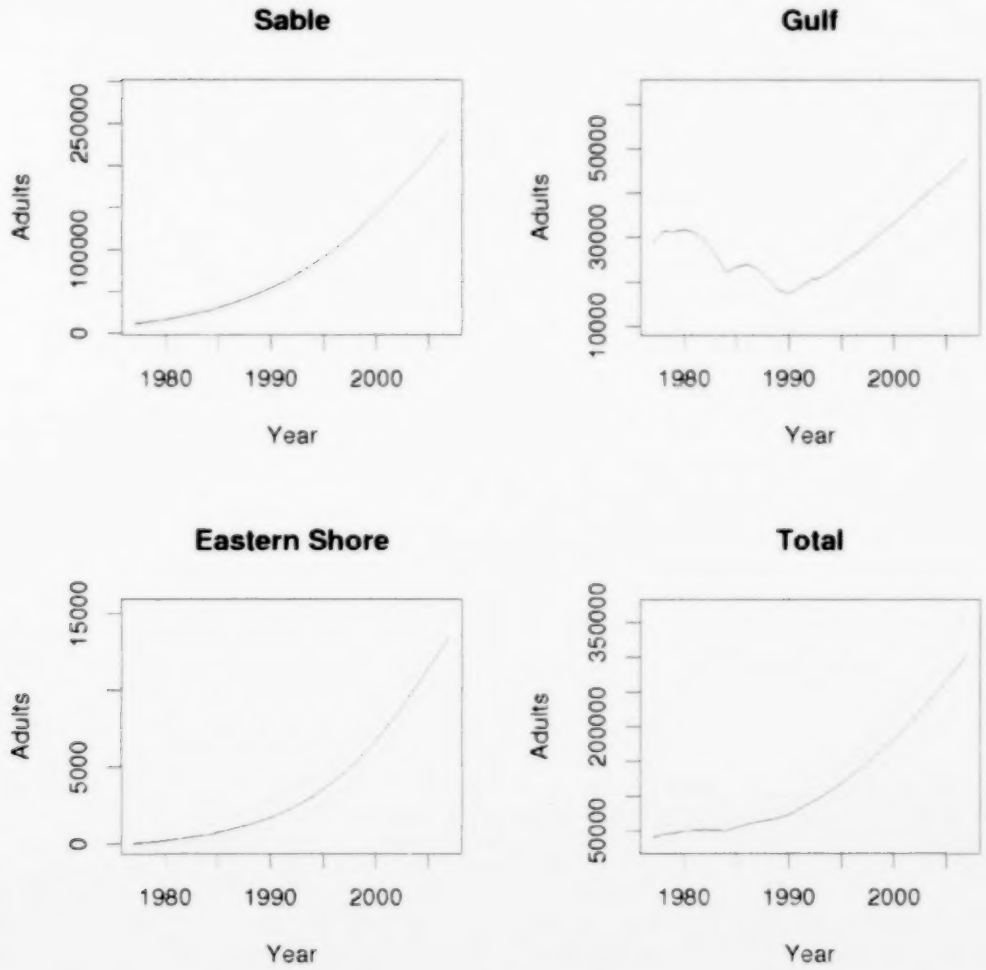

Figure 2. Estimated trajectories and 95% credibility limits of the different herds and the total Northwest Atlantic grey seal population.

Fisheries and Aquaculture Management requested that four harvest scenarios be examined within the context of a five-year management plan that ends in 2010. Results are based on 20,000 simulations and all populations were projected forwards 20 years (Table 4).

Table 4. Harvest scenarios examined including different age compositions and levels of total allowable Catch (TAC). YOY stands for young of the year, 1+ stands for animals aged 1 year and older.

Scenario	Age composition	TAC
A	50% YOY, 50% 1+	15,000
B	50% YOY, 50% 1+	30,000
C	90% YOY, 10% 1+	15,000
D	90% YOY, 10% 1+	30,000
E	50% YOY, 50% 1+	40,000
F	50% YOY, 50% 1+	50,000
G	90% YOY, 10% 1+	40,000
H	90% YOY, 10% 1+	50,000

All scenarios would respect the management objective until the end of the management plan in 2010.

Under a TAC of 15, 000 animals the predicted L20 population trajectory increased over a period of 5 years and 20 years (Scenarios A, C); Table 5). With an increased TAC of 30,000 animals (Scenarios B, D), the predicted L20 population trajectory respected the management over the 5 projection, but declined below N70 after 20 years. Increasing the TAC to 40,000 animals (scenarios E,G), the predicted L20 population trajectory respected the management plan over the 5 year projection, but declined to 0 with an age structure of 50% YOY:50% 1+ animals after 20 years. However, the L20 projection continued to increase after 20 years with an age structure of 90% YOY:10% 1+ animals. Increasing the TAC to 50,000 animals (scenarios F,H), the predicted L20 did not respect the management plan over a 5 year period for an age structure of 50% YOY:50% 1+ animals, but did respect the management plan under the scenario of 90% YOY:10% 1+ animals.

Table 5. Predicted L20 trajectories of the population 5 and 20 years into the future under different harvest scenarios and TAC allocations by region.

Scenario	L20 after 5 years	L20 after 20 years	Sable Island allocation	Gulf allocation	Eastern shore allocation
A	311,000	400,000	11,941	2,378	666
B	266,000	151,000	23,882	4,757	1,332
C	340,000	549,000	11,941	2,378	666
D	322,000	453,000	23,882	4,757	1,332
E	235,000	0	31,842	6,341	1,776
F	201,000	0	39,803	7,927	2,220
G	308,000	399,000	31,842	6,341	1,776
H	291,000	294,000	39,803	7,927	2,220

Sources of Uncertainty

The non-Sable island component of the population breeds on small islands and on the pack ice in the Gulf of St. Lawrence. This may be related to changes in ice conditions, resulting in high pup mortality or the displacement of animals to other sites prior to completion of counts. Further analyses should consider ice cover as a covariate when examining this variability. The

population model did not find any evidence of density-dependent changes in pup production. This is because the reproductive rate data incorporated into the model were from animals sampled in the Gulf of St. Lawrence. This does not agree with published evidence that changes are occurring in the age at first birth in the Sable Island component of the population. The impacts of these changes need to be investigated, but it is likely that our estimate of total population size is conservative. The fit of the model to the Gulf and Eastern Shore pup production data is poor, possibly because of uncertainty associated with the effects of variable ice conditions on Gulf pup production and the limited survey information available for the Eastern Shore colonies. Currently, harvesting is directed towards the Eastern Shore and Gulf components of the population, while the Sable Island herd is protected. The available reproductive data used in the model are for the Gulf and Eastern Shore components of the population, which are also the targeted groups for the commercial harvest. Although large numbers of nuisance seal licences have been issued, there is no information available concerning the number of animals removed under this program, with the exception of 2007. Almost all of these licences have been issued in Nova Scotia. Finally, the commercial harvest is supposedly directed against young of the year, but some recent incidents have determined that adults are being killed as well. The age composition of the commercial harvest as well as the nuisance seal harvest need to be clarified.

For the scenarios reported here, harvests that were composed of 50% YOY:50% 1+ animals had a much more significant impact on the population than did the scenarios that were composed of 90% YOY. This is because of higher expected YOY mortality rates. Harvests of large numbers of adults will also have an immediate impact on pup production and thus the impacts of an adult harvest can be detected almost immediately because pup counts are the main monitoring tool. However, the impacts of a high harvest of 90% YOY will not be detected for 5 or more years until young animals mature and begin to produce pups. Thus any changes in management involving harvest levels of pups will not be detected until for 5 or more years later as the affected cohorts enter the breeding population (demographic momentum). Any harvesting regime should consider the longer-term implications of harvest rates due to this demographic momentum.

Suggested TAC levels have been allocated based on the proportional contribution each region makes to overall pup production. Over the long term this strategy may need to be investigated further because the increase in pup production in the different regions is occurring at different rates. Within regions, hunting effort should not be focussed on any single colony because it may affect the longer term viability of that colony.

ADDITIONAL STAKEHOLDER PERSPECTIVES

Grey seals are considered by the commercial fishing industry as an important factor limiting the recovery of groundfish stocks in eastern Canada. Grey seals are also important hosts for the nematode parasite, *Pseudoterranova decipiens* which must be removed from filets of some commercial fish species during processing. Although not pathogenic the worms are a cosmetic nuisance and increase costs associated with processing of fish. High worm burdens will reduce the quality rating of the filet, reducing the added on value. Grey seals also take baits from lobster traps and fish from gill nets and longlines and are known to break fishing gear. The value of this damage throughout Atlantic Canada has not been quantified in recent years.

CONCLUSIONS AND ADVICE

In 2007, a new assessment was completed, which enabled moving grey seals from the Data Poor to a Data Rich category. Under OBFM, harvest levels for Data Rich populations are to be set to maintain the population above 70% of the observed maximum population size.

Overall, the Northwest Atlantic grey seal population continues to grow, driven by increases in the component of the population breeding on Sable Island. However, harvesting is directed towards the Eastern Shore and Gulf components of the herd, where there is much less certainty associated with the dynamics of these components of the population. It will be important to better understand factors affecting pup production in the Gulf, rates of movement among the three components of the population and improved reproductive rate data for the Sable and non-Sable Island herds. A TAC of up to 40 000 animals with an age composition of 50% YOY and 50% 1+ animals and up to 50,000 animals with an age composition of 90% YOY: 10% 1+ animals would respect the management objectives to maintain an 80% probability that the population was 210 000 animals or greater. More information is needed on where animals are actually harvested and the age composition of this harvest. There are a number of nuisance seal permits that have been issued in Nova Scotia. The numbers of animals killed under this permit system needs to be determined and taken into consideration when setting harvest levels.

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FOR MORE INFORMATION

Contact: Mike Hammill
Maurice Lamontagne Institute
850, route de la Mer
PO Box 1000
Mont-Joli, Quebec, G5H 3Z4

Tel. : (418) 775-0580
Fax: (418) 775-0740
E-mail : Mike.Hammill@dfo-mpo.gc.ca

Don Bowen
Bedford Institute of Oceanography
1 Challenger Drive
Dartmouth, Nova Scotia
B2Y 4A2

(902) 426-8909
(902) 426-1509
Don.Bowen@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Quebec Region
Fisheries and Oceans Canada
Maurice Lamontagne Institute
P.O. Box 1000
Mont-Joli (Quebec)
G5H 3Z4

Telephone: (418) 775-0825
Fax: (418) 775-0679
E-Mail: Bras@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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